Runoff and rainfall distribution in the Selbe river basin (Session 6: Large Scale Energy and Water Balances studies)

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Abstract

Understanding the concept of the hydrological cycle is a crucial point from which to begin the study of Hydrology and has very important practical application value. In another words hydrologist must be able to deal quantitatively with the interrelations between the three main phases of the hydrological cycle: precipitation, evapotranspiration and runoff. Study, which deals the hydrological cycle, used to call as watershed or water balance study. Water balance study allows to collect adequate and complex data which is essential to any sciences and output from such studies could find its application in hydrological modeling and other related studies such as meteorology, agrometeorology, climate change and anthropogenic influence.

This paper summarizes results of rainfall-runoff experiment conducted in the Selbe basin in 1998-2000. The hydrological experimental basin Selbe was established in 1998 by the Hydrology section of the Institute of Meteorology and focussed on the investigation of the water balance and hydrological processes such as runoff formation.

The experiment consists of rainfall measurement at 4 raingauge sites and flow measurement at 2 gauges in upstream and down stream basins (Fig 5.) The analysis in this studies mainly concerned rainfall and runoff distribution of the basin. Rainfall data have been represented as basin spatial and temporal distribution and compared by years and sites. Flow regime of the Selbe river was identified for the period of experiment. The monthly actual evapotranspiration was calculated as monthly loss, namely the difference between precipitation and runoff in the experimental watershed.

The selected Selbe river basin is located in center of Mongolia, near capital city of Ulaanbaatar, between the latitudes of 47° 55' - 48° 15'N and the longitudes 106° 50'-107° 00'. The Selbe with 26.2 km length is draining an area of nearly 220 km^2 that originates from Khentii mountain at elevation of 1850 m and flows through the northeast part of Ulaanbaatar City to Tuul river. Land use types are described as pasture and forest (forest area 54.2 %).

Climate in the basin preserves climate of the whole region and is harsh continental with clear high seasonality. The mean annual mean air temperature is –2.0°C and The annual basin precipitation in the basin is 264 mm. Rainfall patterns are highly seasonal and nearly 90 per cent of total annual precipitation fall within warm period from May to October.

Rainfall varies geographically and temporally. It varies from one watershed to another and from one point to another some distance away within the same cathment area. As mentioned early that the Selbe river basin is considered as mountain region. Therefore, the spatial distribution of rainfall effected by many influencing factors and depends upon the atmospheric circulation and local topographic factors such as surface roughness, relief, slope, as well as their interactions.

During the three years experiment the rainfall have measured totally at 4 sites and 3 of them covers all 3 years period and therefore, comparison analysis have made only for 3 simultaneous sites.

First point, concerning rainfall analysis in this study is basin mean rainfall on monthly and annual base and such analysis is done in simple comparative way between years and sites (Table 1.).

Table 1. Monthly rainfall in the Selbe river basin

No.	Years	V	VI	VII	VIII	IX	X	Sum for warm period
1	1998	1.4	47.2	71.0	72.8	43.1	6.3	242.3
2	1999	10.0	60.1	58.1	56.0	47.2	9.1	240.5
3	2000	11.0	25.7	93.6	127.5	13.7	9.0	271.3

Results of basin mean rainfall calculation show that during the experimental period, in the river basin are observed 242.3, 240.5 and 273.3 mm rainfall for the years 1998, 1999 and 2000, respectively. If compare these values with a regional long term mean rainfall for same period then, 1998 and 1999 were 6-8 percent smaller than the normal and year 2000 was relatively wet and exceeds the regional normal of rainfall amount by 8 per cent.

Total rainfall amount during the warm months in 1999 was about 10 percent less than rainfall amount for the same period in 1998 and at the same time about 20 percent less than year 2000. So, 1999 can be considered as relatively dry year and 2000 as wet year during the experimental period.

Spatial distribution analysis of rainfall is key point for such experiment as water balance study and hydrological modeling. Altitudinal differences of the sites vary from 72 m to 252 m and in the region of the river basin rainfall increases with altitude.

Derived altitude dependence in the study basin clearly shows that rainfall increases with altitude and about 15-25 mm of rainfall per 100-meter increase of altitude (Fig 1.)

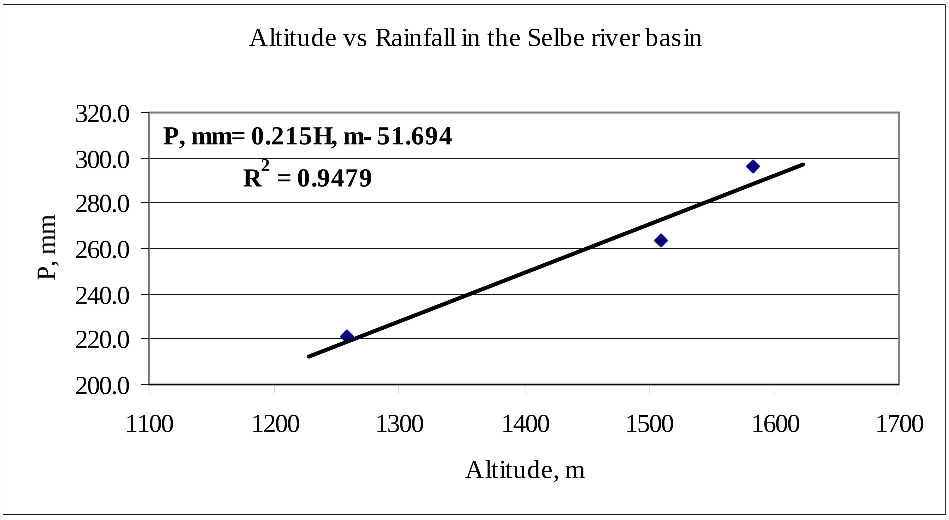

Fig 1. Altitude dependence of rainfall in the Selbe river basin

In this analysis the spatial distribution of rainfall in the basin also presented by cross-correlation analysis between sites (Table 2.) and it shows that as distance between sites increases the magnitude of correlation coefficient decrease from 0.78 to 0.33.

Table 2. Cross-correlation between rainfall sites, R^2, 2000

No.	Sites	Sanzai	Bayanbulag	Yargait	Damba	University
1	Sanzai	**1.0**	0.68	0.50	0.41	0.33
2	Bayanbulag	0.68	**1.0**	0.78	0.59	0.50
3	Yargait	0.50	0.78	**1.0**	0.69	0.54
4	Damba	0.41	0.59	0.69	**1.0**	0.75
5	University	0.33	0.50	0.54	0.75	**1.0**

During the measurement in 2000, the raingauges installed so that at Bayanbulag sites in front side of hill and at Yargait sites in back side of hill. Such way of installation of raingauges allows to reveal effect of exposure to rainfall amount and results of experiments show that lee side rainfall amount is approximately 10 per cent greater than fore side's amount.

As for runoff study the upper catchment runoff response is represented by discharge measurement at Sanzai station, that has a catchment area of 34.2 km^2 and lower one is represented by Damba station with catchment area of 188 km^2.

Typically, the Selbe river reflects primarily the snowmelting in April and May then follow warm low flow period and in July through September summer rainfall dominate with several storm peaks. During the experiment have observed 2 distinguished flow regime and runoff formation types. If in 1999 the spring snowmelt flood was dominated in flow regime of the river then 2000 was clearly year with dominance of summer rainfall floods (Fig 2 and 3) Relatively high spring flood in 1999 reasoned by quite deep snowpack in wintertime and very sudden warming in early spring, which causes quick and intensive snowmelt.

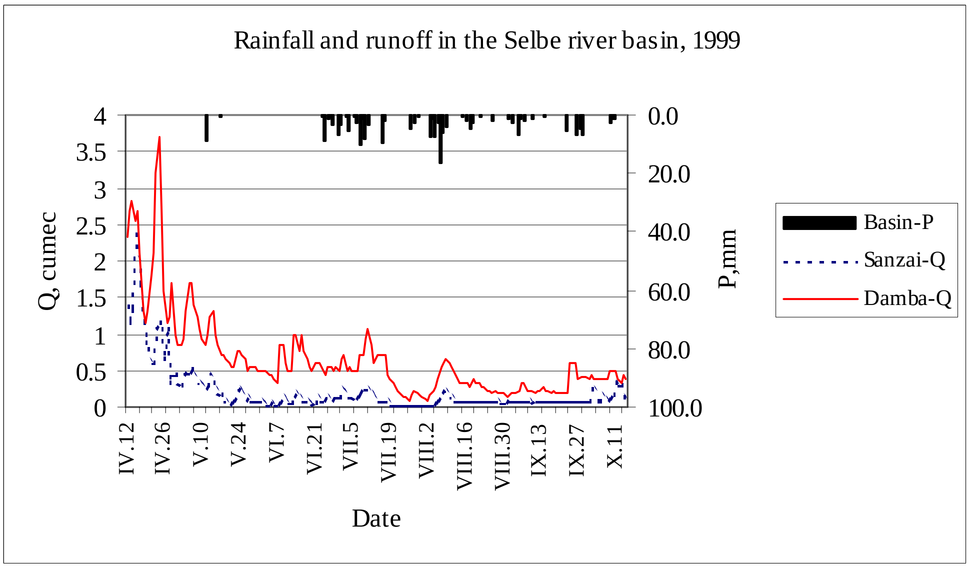

Fig 2. Rainfall and runoff distribution in the Selbe river basin (1999)

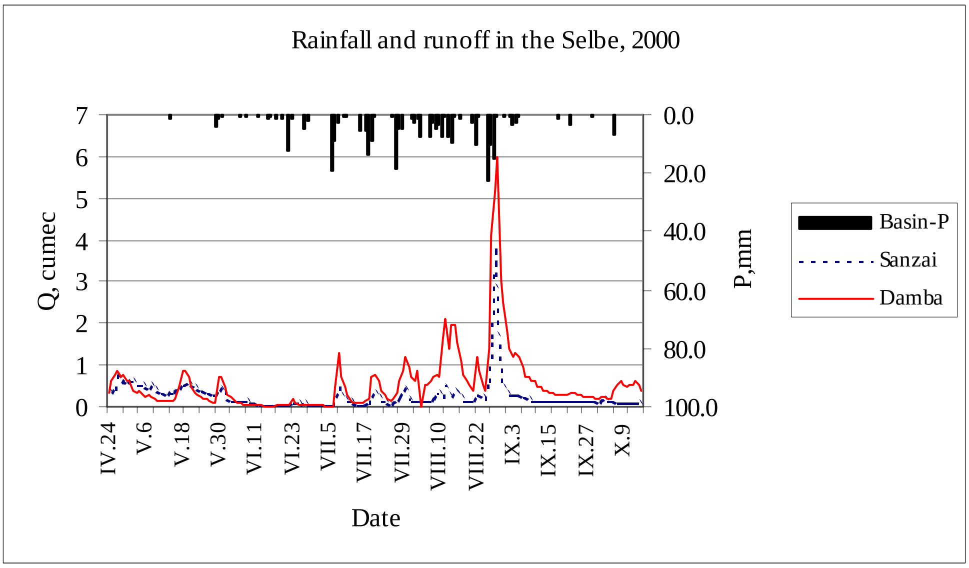

Fig 3. Rainfall and runoff distribution in the Selbe river basin (2000)

Water balance of the basin represented by simple water balance equation and evapotranspiration is calculated as difference between rainfall and runoff on monthly base, separately for upper and lower river basins. Typical water balance distribution in time its component's ratio is shown in Fig 2.

Results of basin evapotranspiration analysis shows that from 70 up to 96 percent of rainfall lost by evapotranspiration in dry periods (June and July) and it decreases up to 30-40 per cent in September and October.

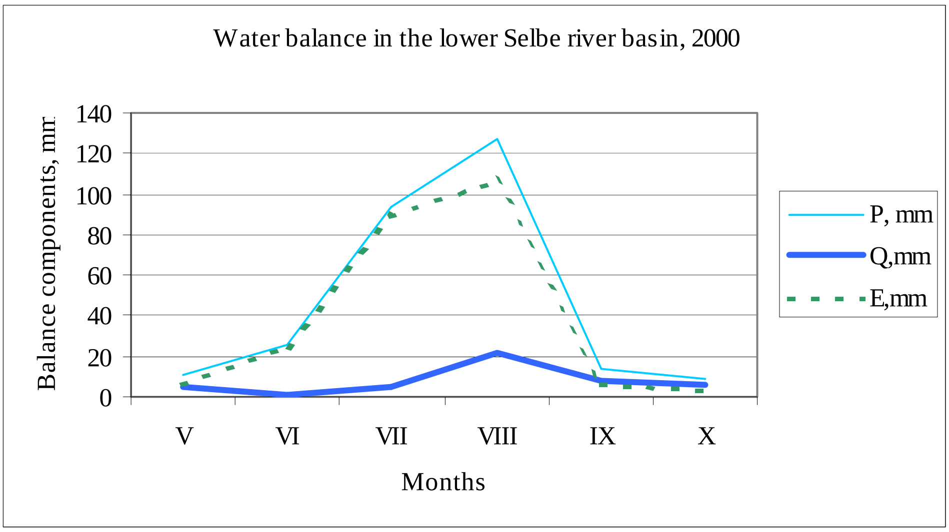

Fig 4. Water balance in the Selbe river basin (2000)

The present study is considered as a preliminary analysis of the available data with some traditional techniques and in future we plan to collect more suitable data to reveal more detailed characteristics of runoff formation and interrelations between water balance components in space and time by establishing complex water balance experiment site.

Conclusions from this study concerns the following points:

- Rainfall pattern in the Selbe river basin has clear spatial and temporal variation. In dry years up to 50 and in wet years up to 80 percent of total rainfall fall within 2 months July and August. As for spatial distribution, rainfall in the Selbe river basin increases with altitude in magnitude of 12-25 mm per 100-meter increase of elevation.
- Nearly 65 and 60 per cent of annual runoff forms during the periods of snow melting and rainfall dominance, respectively. The catchment runoff response is different for upper and lower basin due to geographic conditions and consequently runoff volume or runoff coefficient is higher in the upper basin (at Sanzai) than the lower basin (at Damba) about 2-3 times.
- From the water balance analysis can conclude that on average 60 per cent of rainfall in the basin is lost by evapotranspiration and this ratio changes from 40 to 90 per cent in wet and dry periods of the year, respectively. The study also shows that evapotranspiration in lower river basin was 10 per cent greater than upper one, which is indication of difference of climate and geographic factors of the basins.

Finally, would like to conclude that it is required to continue such study in the basin to reveal details of runoff formation and interrelation between water balance components with emphasis for evapotranpiration, climate factors, soil moisture study.

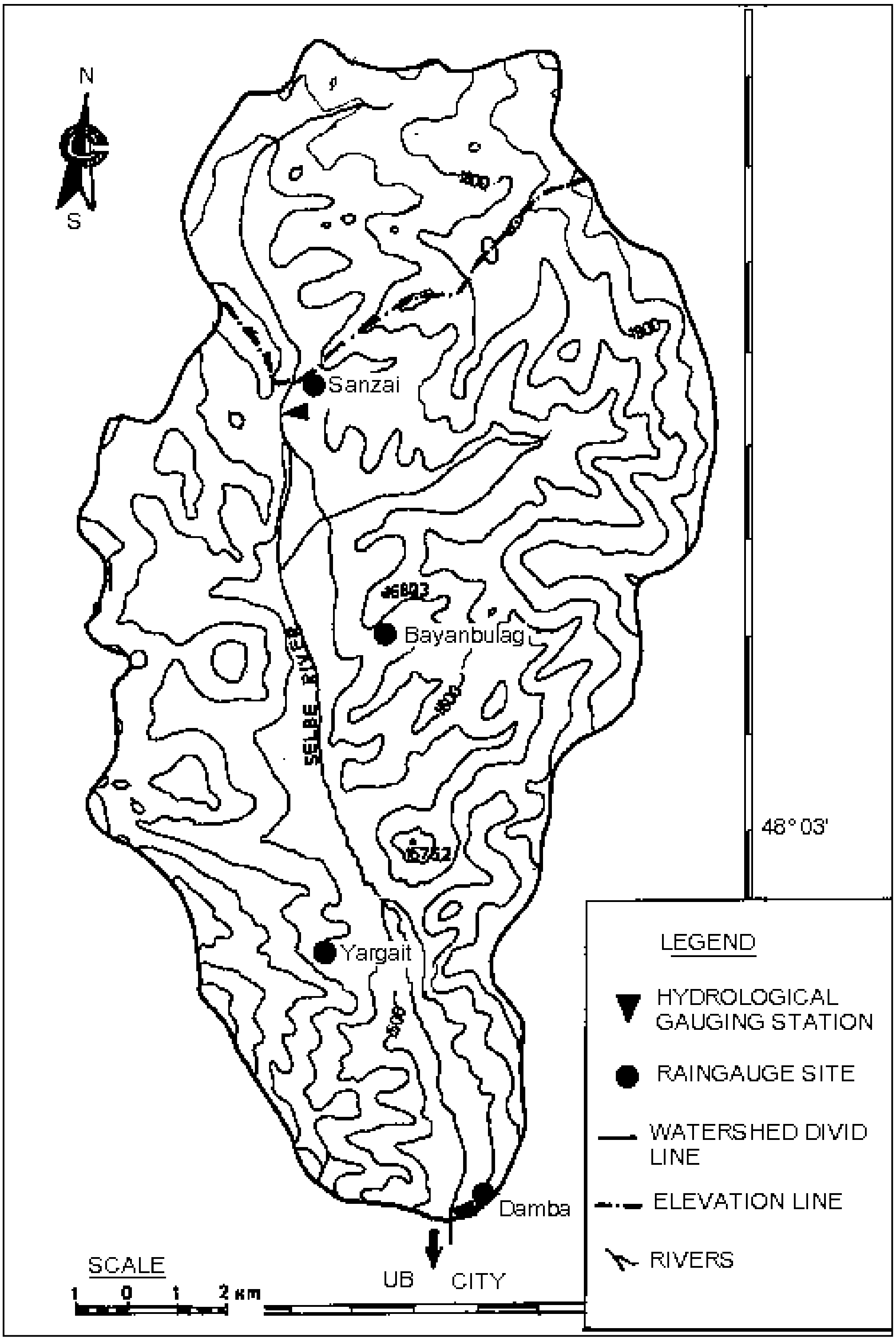

Fig 5. Locations of rain and runoff gauges in the Selbe river basin